A Computational Homogenization Method for the Evaluation of Eddy Current in Nonlinear Soft Magnetic Composites

I. Niyonzima[1], R. V. Sabariego[1], P. Dular[1,2], and C. Geuzaine[1]

[1] Department of Electrical Engineering and Computer Science,
Montefiore Institute B28, B-4000 Liège, Belgium.
[2] Fonds de la Recherche Scientifique - FNRS, Belgium.E-mail:
iniyonzima@doct.ulg.ac.be

The use of the soft magnetic composite (SMC) in electric devices has increased in recent years. These materials made from a metallic powder compacted with a dielectric binder are a good alternative to laminated ferromagnetic structures as their granular mesoscale structure allows to significantly reduce the eddy current losses. Furthermore unlike the laminated ferromagnetic structures, SMC exhibit isotropic magnetic properties what makes them good candidates for manufacturing machines with 3D flux paths. The isotropy of the thermal conductivity also allows for a more efficient heat dissipation.

The use of classical numerical methods such as the finite element method to study the behavior of SMC is computational very expensive. Indeed a very fine mesh would be required in order to capture fine scale variations i.e. variations at level of metallic grains whence the use of multiscale methods for modelling SMC. The application of multiscale method to study the behaviour of SMC is relatively recent. In (A. Bordianu *et al* “A Multiscale Approach to Predict Classical Losses in Soft Magnetic Composites”, IEEE Trans. Mag., vol. 48, no. 4, 2012.), the authors used a homogenization technique to pre-compute electrical and magnetic constitutive laws of an equivalent homogenized medium on a representative volume element (RVE). These laws were then used in finite element computations. Herein, the RVE has been chosen to account for the grain-grain contact that can occur in a actual SMC structure due to the compaction process and that can lead to the appearance of macroscale eddy currents.

In this paper, we will extend the computational homogenization method successfully used for modelling the behaviour of laminated ferromagnetic cores in magnetodynamics (I. Niyonzima *et al* “Computational Homogenization for Laminated Ferromagnetic Cores in Magnetodynamics”, in Proc. of the 15th Biennal Conference on Electromagnetic Field Computation, 2012) to the case of SMC. The method is based on the heterogeneous multiscale method (HMM) and couples two types of problems: a macroscale problem that captures the slow variations of the overall solution and many microscale problems that allow to determine the constitutive laws at the macroscale. The choice of RVE will also be discussed.